Space Shuttle
Technology Summary

Main Engine Alternate Turbopump Development

Developed in the 1970s by Marshall Space Flight Center in Huntsville, Ala., the Space Shuttle Main Engine is the world's most sophisticated reusable rocket engine. In 1983, NASA began undertaking major improvements to the Main Engine with the formal Phase II engine development program. The primary goal was to improve the engine's reliability, durability and safety with a series of enhancements.

The first modification was the Block I engine, flown in 1995. The engine contains two powerful high-pressure turbopumps – made by Pratt & Whitney of West Palm Beach, Fla. – that supply up to 970 pounds (440 kilograms) of liquid oxygen per second and up to 162 pounds (73 kilograms) of liquid hydrogen fuel per second to the engine's main combustion chamber.

The liquid oxidizer turbopump was part of the engine's redesign. The Block I engine also incorporated a two-duct powerhead, which improved the distribution of the fuel flow and reduced the pressure and temperature in the engine, and a single-coil heat exchanger, which eliminated welds and increased reliability. In addition, the engine included new bearings made of silicon nitride, a ceramic material that is 30 percent harder and 40 percent lighter than steel and whose ultra-smooth finish produces less friction during pump operation.

The Block IIA engine – first flown in 1998 – added a large throat main combustion chamber to the existing Block I engines. The throat of the new chamber is about 10 percent larger – improving the engine's reliability by reducing pressure and temperature in the chamber and throughout the engine. The enlargement allows the high-pressure pumps to operate at lower turbine temperatures and pressures.

In another redesign feature, the new large throat combustion chamber is cast from large pieces of metal, reducing the number of welds. This increases reliability of the chamber as well as reduces labor, assembly time and maintenance.

The latest modification – to be flown in 2001 – will be the Block II engine. It incorporates the changes incorporated in the Block I and Block IIA and adds a new high-pressure hydrogen turbopump.

The current hydrogen turbopump design – with 20-year-old technology – requires pump removal and maintenance between flights, and calls for special coatings for thermal protection to the turbine blade airfoils. It also features welded construction, which requires meticulous inspections.

The new design uses a unique casting process to eliminate welds, significantly increasing the number of missions between major overhauls, and eliminates the need for some special coatings.